

# Enabling robots to achieve new levels of factory automation



**Tobias Puetz**  
*Systems engineer,  
Factory Automation and Control  
Texas Instruments*

# **For more than half a century, robots have played an ever-increasing role in manufacturing, successfully transforming industries ranging from automobiles to electronics to consumer goods. Robots bring productivity, cost-efficiency and often greater safety to repetitive task performance.**

---

Robots continue to evolve, offering greater functionality, flexibility, range of motion, speed and precision. Besides functioning in protected spaces on assembly lines, robots increasingly operate side by side and interact with human beings, and in some cases move materials from place to place. For robots to operate in these ever-more-complex ways, they must be able to process a great deal of sensing data about the environment, communicate with each other and with centralized control units, and perform control functions that adapt to environmental changes and keep them from harming human beings.

By providing innovative electronic solutions for industrial automation, Texas Instruments (TI) offers a full range of integrated circuit (IC) products that enable advanced robot system development. TI provides both individual products and complete solutions for control, communications, power and safety, from the highest control layer in a factory down to actuators and sensors. TI systems expertise is based on many years of engagement with leading manufacturers in many industries, and the company's in-depth support helps customers simplify the design of robotic systems and reduce development time.

## **Types of robotic applications in industrial automation**

Despite the widespread attention given to human- and animal-like robots, drones, and even robot vacuums, robots used in industrial settings remain the mainstay of the robotics market. Many of

the concerns that robot developers face when designing products for industrial use also apply to other areas of robotics, and the technology created to handle factory requirements often enables new robot applications outside of manufacturing.

While all robots used in industrial automation are technically industrial robots, for the purposes of this discussion it will be distinguished between three groups of robot applications: industrial robots, logistics robots and collaborative robots.

Industrial robots are units fixed in place to handle tasks such as welding, painting, picking and placing, assembling, and lifting objects to set them on pallets or in containers. Control signals come from a robot controller, which is a control unit in a cabinet usually located at the base of or next to the robot. Industrial robots are designed to perform tasks quickly, accurately and without direct interaction with humans. Thus, they have no sensors to perceive



*Figure 1. Robot applications in industrial automation and service.*

the presence of people, and are not designed to accommodate people within their operational space. When human interaction is necessary, the robot usually will be deactivated if someone is in its working area. For human safety and noninterference with operation, industrial robots are usually located inside fences, transparent walls, light-activated barriers, arrays of floor mats that cut off power when stepped on, and other protective barriers.

Logistics robots are mobile units that operate in environments where there may be people present, such as warehouses. Logistics robots might fetch goods and bring them to a packing station, or transport goods from one building of a company site to another; one recent development has [robots delivering takeout](#), although they are currently accompanied by a human “handler.” These robots typically move within a particular environment and need a number of sensors for localization, mapping and to prevent collisions, especially with humans. Ultrasonic, infrared and light detection and ranging (LIDAR) sensing are all possible

technologies. Because of this robot’s mobility, the control unit is located inside of it, often with wireless communication to a central remote control.

Collaborative robots offer the most complex interaction with humans, often working directly with a person on the same object at the same time. A collaborative robot might hold an object while a worker visually inspects it, or perhaps perform fine-tuning tasks. The robot might then set the object down in an area where another robot can pick it up, possibly to move it in collaboration with a different worker.

Collaborative robot makers must implement a high level of environmental sensing and redundancy into robot systems to quickly detect and prevent possible collisions. Integrated sensors connected to a control unit will sense the collision between a robot arm and a human or other object; the control unit will turn the robot off immediately. If any sensor or its electronic circuit fails, the robot also turns off. Collaborative robots are typically fixed in place with a control unit in a cabinet, but can also be mounted onto a vehicle.

## Technology requirements for industrial robotics

Manufacturers who invest in robots are looking for greater productivity, coupled with a good return on investment in a reasonable time. Achieving these goals depends on precision during difficult tasks, performance speed for highly repetitive tasks, safety during dangerous tasks, or some combination of these capabilities.

Robots with flexible application capabilities, often using cameras to “see” objects, can save investment on more specialized machines, complete shorter production runs efficiently, and enable new uses on the factory floor. In addition, many factories today are adding more layers of communication and control to production lines, bringing together more data for better process control and equipment maintenance while also making processes more responsive to changing product demands. Robots and other equipment that communicate among themselves and with higher-level control are essential to fully integrated factories.

Robot developers rely on advanced IC solutions to meet these requirements. IC products that enable advances in industrial robots must provide precise sensing, high-speed sensor signal conversion, fast computation/signal processing for real-time response and high-speed communications. ICs also enable high efficiency and small-form-factor power supplies in conjunction with advanced semiconductors like gallium nitride (GaN) field-effect transistors (FETs).

All of these factors are especially important as the number of sensors and environmental stimuli increases. Robot developers depend on solutions that minimize the headaches of circuit design and certification, speeding the development of products that they can deliver to industrial customers quickly.

Advanced ICs must offer features that include:

- A high-efficiency, high-voltage power supply with circuit protection and low-noise emissions
- Characterization for an extended temperature range
- Support for industrial ethernet and other widely used industrial communication standards
- Ease of programming for greater flexibility
- Fast, precise analog-to-digital and digital-to-analog signal conversion
- Reinforced isolation to meet industrial safety standards
- Control redundancy for safety-critical applications when combined with other ICs
- A small footprint when placing circuitry in tight spaces such as mobile logistic robots, or for motor control in robot arms (not to mention other equipment with tight spaces, such as sensors and motor housings)
- Low power consumption (critical for battery- or ambient-powered equipment such as logistics robots and sensors)
- Comprehensive support, including reference designs and evaluation modules (EVMs) to minimize design time and let designers focus on value-added technology



*Figure 2. Assembly line with robots interacting.*

## TI's enabling technology for industrial robots

TI offers the full range of advanced technology needed to design flexible robots that operate within the environment of today's integrated manufacturing plants. From sensor input to actuator or motor output, from individual equipment units to factory-level control and beyond, TI solutions handle the entire signal chain, as well as the processing and power required for robotic applications. Products include features such as reinforced isolation, and are tested and qualified for use in harsh industrial environments. To close the circle, TI backs its IC products with in-depth support that simplifies design and speeds development.

Among the many solutions that TI offers for robots and other industrial equipment, these are especially notable:

- **Sitara™ processors.** The heart of any control unit is the processor, and TI's system-optimized Sitara processors are designed for flexible, fast design in robots and other industrial equipment. Based on ARM® Cortex®-A cores, Sitara processors provide flexible peripherals, connectivity and unified software support to cover a wide set of applications. A broad portfolio of single- and multicore devices provides a selection that offers the perfect balance of integration, connectivity and performance for every application. A fully scalable software platform enables a unified software experience for simplified development and code migration across Sitara processors and TI digital signal processor (DSP) families. Pin-compatible options within processor families make hardware upgrades seamless.

Sitara processors are designed to meet industrial requirements for long-term applications, with product life cycles typically in excess of 10 years. The devices provide programmable flexibility when

implementing specialized data-handling operations, custom peripheral interfaces, and fast real-time responses as short as 5 ns. The programmable real-time unit inside the industrial communication subsystem (PRU-ICSS), which exists as a hardware block inside the Sitara processor family, replaces field-programmable gate arrays (FPGAs) or application-specific ICs (ASICs) with a single-chip solution. Easy access to free software and design tools, plus a large base of open-source community support, reduce barriers to development.

- **Proximity sensing.** Collaborative robots require sophisticated sensing of nearby things and people in order to make them safe. TI's expertise in sensing technology includes solutions for proximity sensing in applications that detect the presence of a target object and, if required, measure its distance. Techniques that TI supports for proximity sensing include ultrasonic, magnetic, capacitive, inductive and time-of-flight (ToF).
- **3-D ToF/optical sensing.** TI products enable ToF-based sensing to go beyond proximity detection to next-generation machine vision. TI's 3-D ToF chipsets allow for maximum flexibility to customize designs for robot vision and other applications. Tools include an EVM and a highly configurable camera development kit (CDK); the latter provides a 3-D location of each pixel for accurate depth maps that aid customization for a given application.
- **GaN power.** In addition to an extensive power management portfolio of switching and linear regulators, switching controllers, power monitoring and other supporting power management devices, TI offers GaN modules, drivers and controllers that provide outstanding power density for high-voltage power supplies in industrial systems.

GaN technology greatly reduces switching losses and therefore enables faster switching speeds while reducing or eliminating heat sinks. Easy-to-use modules provide a complete solution with optimized layout and efficiency, along with minimum electromagnetic emission and noise for compliance with industrial standards. Complete support includes EVMs, development boards and a quick-start toolset to speed design. For accurate control of precision drives, TI's reference design library includes a [48V 3-Phase Inverter with Shunt-Based In-Line Motor Phase Current Sensing Reference Design](#).

- **Industrial ethernet.** TI's in-depth expertise in network communications means support for a wide range of standards. To aid in the development of systems using real-time industrial ethernet, TI offers a [reference design](#) that enables customer applications to exchange process data between the master and devices within a 4- $\mu$ s cycle time. The protocol includes essential setup tasks, and open-source firmware enables product differentiation.

## Building better robots for the integrated factory

As manufacturing continues to become more highly integrated at all levels, robots will play an ever-increasing role in carrying out a wide variety of assembly tasks that increase production and make the workplace safer for human beings. Traditional industrial robots, logistics robots and collaborative robots have their jobs to do, and robot developers look for solutions that enable accurate, safe, cost-effective operation from all of them.

TI's IC products for signaling, processing, communications and power management provide the complete solutions that robotics manufacturers need. TI backs its semiconductor and IC products with software tools, EVMs and reference designs, and other forms of support that help make the work of designing robots faster and more profitable. As robots are improving manufacturing, TI is helping developers improve robots. For more information, visit our [Robotics](#) web page.

**Important Notice:** The products and services of Texas Instruments Incorporated and its subsidiaries described herein are sold subject to TI's standard terms and conditions of sale. Customers are advised to obtain the most current and complete information about TI products and services before placing orders. TI assumes no liability for applications assistance, customer's applications or product designs, software performance, or infringement of patents. The publication of information regarding any other company's products or services does not constitute TI's approval, warranty or endorsement thereof.

The platform bar and Sitara are trademarks of Texas Instruments. All other trademarks are the property of their respective owners.

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated